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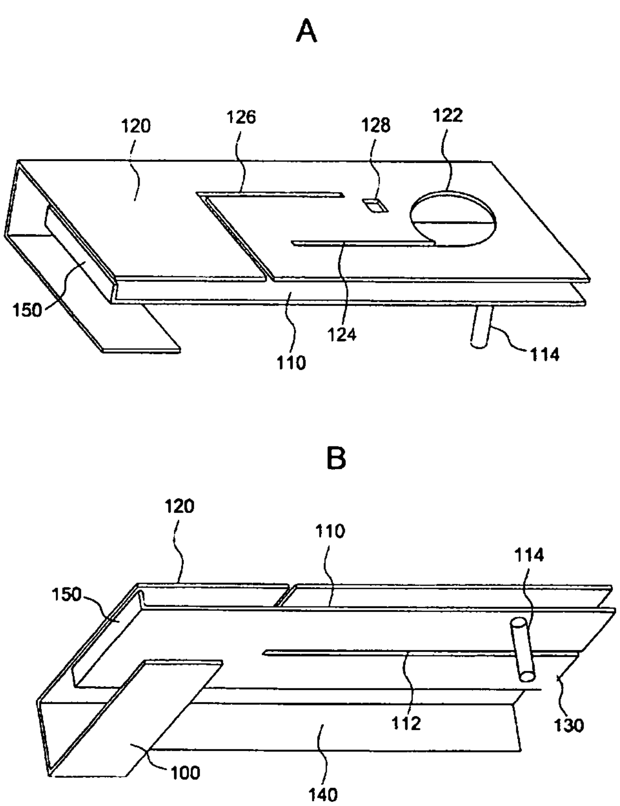

(57) Abstract: An internal antenna showing high radiation efficiency and having a wide operation bandwidth while minimizing reflection loss due to dielectric material. A ground conductor (100) is electrically to ground of a PCB of a portable terminal. A first conducting plate (110) is disposed parallel with the ground conductor (100).Feeding means (112) is installed beneath the first conducting plate (110) to feed signal from a feeding point of the terminal to the first conducting plate (110) and feed signal from the first conducting plate (110) to the feeding point. A second conducting plate (120) is disposed parallel with the first conducting plate (110) and a connection conducting plate (130) connects the first and second conducting plates (110, 120).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNAL ANTENNAS FOR PORTABLE TERMINALS AND MOUNTING METHOD THEREOF

Technical Field

The present invention relates to an antenna for a portable terminal and, more particularly, to an internal antenna which is mounted inside the portable terminal. Also, the present invention relates to a method of mounting such an antenna.

Background Art

Currently available antennas for portable terminals include a monopole antenna having an electrical length of $\lambda/4$ (where, λ is a wavelength), a helical antenna having an electrical length of $\lambda/4$, and a retractable antenna which is a combination of a monopole antenna and a helical antenna. Since all these antennas are installed or exposed outside the terminal, the antennas are being regarded as one of the major obstacles in miniaturizing the terminal. Accordingly, much efforts are being exerted to develop internal antennas which can be mounted directly on a surface of a printed circuit board of the terminal.

Antenna technologies for implementing the internal antennas include an inverted-F type antenna technology utilizing probe feeding in a radiator, a microstrip patch antenna technology using printed circuit board technology, and a ceramic chip antenna technology using ceramic material of high dielectric constant. However, the internal antennas according to the above technologies are confronting a design problem that the bandwidth of an antenna decreases with the size of the antenna. The inverted-F type antenna has a

narrow bandwidth and thus is inadequate for a terminal which is used for a wideband service. The ceramic antenna is disadvantageous in that the loss in the antenna gain may be large because of the high dielectric constant of the ceramic dielectric material. On the other hand, the microstrip patch antenna, which is advantageous in that the frequency tuning and the increase of the bandwidth is facilitated owing to the various slots and stacking skills, has a drawback that the antenna itself may be bulky.

Thus, in order to satisfy needs on wideband communication services in the case that another kind of wideband communication service such as IMT-2000 is provided in addition to the currently available services, an antenna technology which enables a single antenna to cover multiple band services and show a high radiation efficiency is required. In other words, internal antenna of a new concept outstanding over a current internal antenna is strongly needed.

Disclosure of the Invention

To solve the above problems, one object of the present invention is to provide an internal antenna which shows a high radiation efficiency a wide bandwidth with negligible loss caused by dielectric material.

Another object of the present invention is to provide a method of mounting an antenna in a manner that enhances the radiation efficiency.

An internal antenna for achieving one of the above objects includes two radiators disposed parallel in a structure of dual patches. The wide bandwidth characteristics are

obtained by adjusting the distance between the patches so as to result in an electromagnetic coupling and providing a vertical radiator coupled to the patches.

A ground conductor is electrically connected to the ground plane of the printed circuit board, and a first conducting plate is disposed parallel with a the ground conductor displaced by a predetermined distance. Feeding means which is connected to the first conducting plate feeds signal from the feeding point to the first conducting plate and feeds signal from the first conducting plate to the feeding point. A second conducting plate is disposed parallel with the first conducting plate, and a connection conducting plate connects the first conducting plate to the second conducting plate.

Preferably, the internal antenna further includes a vertical conducting plate extending vertically from an edge of the second conducting plate to be electrically connected to the ground conductor. It is preferable that at least one slit is formed penetrating the first conducting plate to provide a signal path. Also, it is preferable that at least one slit is formed penetrating the second conducting plate to provide a signal path.

Meanwhile, according to an aspect of the internal antenna mounting method for achieving another one of the above objects, the internal antenna is first disposed in such a manner that a upper edge of the internal antenna is displaced outwards from an edge of the printed circuit board by a predetermined distance. Then, the ground conductor is connected to a ground of the printed circuit board, and the feeding means is connected to a feeding point of the printed circuit board.

According to an aspect of the internal antenna mounting method, a predetermined portion of a ground plane of the printed circuit board close to an edge is removed, and then

the internal antenna is disposed on the printed circuit board on which the ground plane is removed. Afterwards, the ground conductor is connected to a ground of the printed circuit board, and the feeding means is connected to a feeding point of the printed circuit board.

Brief Description of the Drawings

The above objectives and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIGS. 1A and 1B show an embodiment of an internal antenna according to the present invention;

FIG. 2 shows the internal antenna of FIGS. 1A and FIG. 1B mounted on a printed circuit board of a portable terminal;

FIG. 3 shows a standing-wave ratio pattern of the internal antenna of FIGS. 1A and 1B;

FIG. 4A shows a radiation pattern in electrical field plane of the internal antenna of FIGS. 1A and 1B;

FIG. 4B shows a radiation patterns in magnetic field plane of the internal antenna FIGS. 1A and 1B;

FIGS. 5A and 5B show another embodiment of the internal antenna according to the present invention;

FIG. 6 shows the internal antenna of FIGS. 5A and FIG. 5B mounted on a printed circuit board of a portable terminal;

FIG. 7 shows a standing-wave ratio pattern of the internal antenna of FIGS. 5A and 5B;

FIG. 8A and FIG. 8B show yet another embodiment the internal antenna according to the present invention;

FIG. 9 shows the internal antenna of FIGS. 8A and FIG. 8B mounted on a printed circuit board of a portable terminal; and

FIG. 10 shows a standing-wave ratio pattern of the internal antenna of FIGS. 8A and 8B.

<u>Embodiments</u>

FIG. 1A is a perspective view of an internal antenna according to an embodiment of the present invention seen from the upper side and FIG. 5B is a perspective view of the antenna seen from the lower side. Referring to FIGS. 1A and 1B, the internal antenna according to present embodiment includes a ground conductor 100 electrically connected to ground of printed circuit board (PCB) of a portable terminal (for example, by soldering), a first conducting plate 110 disposed parallel with the ground conductor 100 while being spaced apart from the ground conductor 100 by a certain distance, a second conducting plate 120 disposed over the first conducting plate 110, a connection conducting plate 130 for connecting the first and the second conducting plates 110 and 120 to each other, a vertical conducting plate 140 extending from an edge of the second conducting plate 120 downward to be electrically connected to the ground conductor 100, and a vertical radiating plate 150 extending from an edge of the first conducting plate 110 toward the

second conducting plate 120. Such an antenna is mounted on the PCB of the portable terminal having a ground plane and feeding point.

A first slit 112 penetrating the first conducting plate 110 which operates as a first radiator runs across the center of the first conducting plate 110 to an edge, and thus the first conducting plate 110 is "U"-shaped. Also, a feeding probe pin 114 extends downward from the bottom surface of the first conducting plate 110. One edge of the first conducting plate 110 near the feeding probe pin 114 is connected to the second conducting plate 120 by a connection conducting plate 130.

In the present embodiment, the second conducting plate 120 operating as a main radiator has a rectangular shape. A circular hole 122 penetrates the second conducting plate 120 and a second slit 124 runs from the hole 122 toward the center of the plate. A "L"-shaped third slit 126 is formed to be spaced apart from the second slit 124 by a certain distance. A fourth slit 128 having a rectangular a shape is further provided between the hole 122 and the third slit 126.

The hole 122 divides the signal path of the signal input through the connection conducting plate 130 into two paths along the circumference of the hole 122, i.e. clockwise and counterclockwise, and thus increases the antenna bandwidth. The hole 122 may have a rectangular or triangular sectional shape rather than the circle shape. Since, however, such an angular hole may give rise to a perturbation which prevents from the divergence of the signal, it is preferable that the hole 122 has a circular sectional shape for facilitating the divergence of the signal.

The second slit 124 and the "L"-shaped third slit 126 forms a "U"-shaped signal path along the circumference of the hole 122. The length of the signal path along the circumference of the hole 122 may be adjusted by changing the length and the position of the second and the third slits 124 and 126, which may be used for tuning of the operation frequency of the antenna along with the first slit 112. The fourth slit 128 divides the signal and incudes the perturbation of the divided signals, and thus increases the antenna bandwidth owing to a parasitic radiation.

The vertical radiating plate 150 is spaced apart from the second conducting plate 120 by a certain distance and works as a vertical radiator. The bandwidth of the antenna depends on the electromagnetic coupling between the first and the second conducting plates 110 and 120, also, which may be adjusted by changing the height of the vertical radiating plate 150. Meanwhile, it is preferable to dispose the first and the second conducting plates 110 and 120 to be close in proximity so that the plates 110 and 120 are coupled electromagnetically. In such a case, the electromagnetic coupling between the plates enhances the antenna gain and increases the antenna bandwidth.

In the antenna above, the signal fed from an internal circuit of the terminal to the first conducting plate 110 through the feeding probe pin 114 is provided to the second conducting plate 120 and the vertical radiating plate 150. Thus, the radiation is accomplished by the first and the second conducting plates 110 and 120 and the vertical radiating plate 150. A portion of the signal provided to the second conducting plate 120 is transmitted to the ground conductor 100 through the vertical conducting plate 140. Meanwhile, the signal is received through the first and the second conducting plates 110

and 120 and the vertical radiating plate 150 is provided the internal circuit of the terminal through the feeding probe pin 114.

The first conducting plate 110 has a dominant influence on input impedance characteristics of the antenna because it has a feeding point connected to the internal circuit of the terminal. In particular, the first slit 112 is critical to the operation frequency of the antenna since the length of the first slit 112 determines the total length of the signal path in the first conducting plate 110. Also, the vertical conducting plate 140 connected to a ground plane of the terminal through the ground conductor 100 may work as another vertical radiator, and its height is one of the principal variables which may be used for increasing the antenna bandwidth.

FIG. 2 shows the internal antenna of FIGS. 1A and FIG. 1B mounted on a printed circuit board (PCB) of a portable terminal. As shown in FIG. 2, the antenna is installed such that upper edge of the antenna is displaced upwards from the upper edge of the PCB by a certain offset D1 to maintain the radiation characteristics of the antenna which deteriorates when the ground plane of the PCB is close to the antenna. In an alternative embodiment, the antenna may be installed inside the PCB or to be aligned to the edge of the PCB after the ground plane of the PCB is removed as much as the offset.

FIG. 3 shows a standing-wave ratio pattern of the internal antenna of FIGS. 1A and 1B. In the drawing, the horizontal axis indicates a frequency range [GHz] and the vertical axis indicates a reflection loss [dB]. The internal antenna according to the present invention shows a wide bandwidth characteristics of having an operation bandwidth of about 420 MHZ (1.58 - 2 GHz) with respect to a reference of -10 dB corresponding to a

standing-wave ratio of 2:1. The size of the antenna used in the measurement is 30 x 12 x 4 [mm] and the distance between the first and the second conducting plates 110 and 120 is 1.5 [mm].

FIGS. 4A and 4B show radiation patterns in electrical field plane (or a vertical plane pattern) and in magnetic field plane (or a vertical plane pattern), respectively, of the internal antenna of FIGS. 1A and 1B. It can be seen, in FIG. 4A, that the antenna shows a maximum gain of 2.1 [dBi] at 155 degree which is 25 degrees downwards from a vertical plane of the antenna since the antenna is installed on the top end of the PCB and thus the beam pattern declines to the ground plane. FIG. 4B shows that the antenna shows the maximum gain of 1.3 [dBi] at 190 degree. The size of the antenna used in the measurement is same with that described with reference to FIG. 3.

FIGS. 5A and 5B show another embodiment of the internal antenna according to the present invention. FIG. 5A is a perspective view of the internal antenna seen from the upper side and FIG. 5B is a perspective view of the antenna seen from the lower side. Compared with the embodiment of FIGS. 1A and FIG. 1B, the internal antenna according to the present embodiment has an increased aspect ratio and the slit in a first conducting plate 210 is divided into two shorter slits 212 and 214. Further, slits 224, 226, and 228 in a second conducting plate 220 are formed longitudinally, so that the second conducting plate 220 shows a signal path different from that of the antenna of FIGS. 1A and FIG. 1B. Also, a second vertical conducting plate 260 is further provided at an edge the second conducting plate 220 in addition to a first vertical conducting plate 240.

A fifth slit and a sixth slits 212 and 214 in the first conducting plate 210 forms another signal path crossing between them and induces an increase of the antenna bandwidth owing to the multi-path transmission. The second conducting plate 220 has the a second vertical conducting plate 260 extending downwards from the left edge in addition to a first vertical conducting plate 140 extending from the top edge for the expansion of the bandwidth and the resonance in a higher frequency band, which is described below with reference to FIG. 7.

A seventh slit 224 formed longitudinally contrary to the second slit 124 shown in FIGS. 1A and FIG. 1B enables the signal to flow counterclockwise around a hole 222, which results in a phase difference between a signal flowing left directly from a connection conducting plate (not shown in FIGS. 5A and 5B) and a signal rotating counterclockwise from a lower part of the edge, i.e. the connection conducting plate. Thus the antenna bandwidth may be enlarged because of a parasitic radiation owing to the interference of signals having the phase difference.

Eighth slit 226 disposed periodically to form a shape of a "comb" and multiple ninth slit 228 alternating with the eighth slit 226 provides a zigzagging signal path which is sufficiently long in spite of the small size of the antenna and facilitates a resonance in lower frequency band which is described below with reference to FIG. 7. Besides, the zigzag path formed by the eighth slit 226 and the ninth slit 228 in the present embodiment enlarges the bandwidth through a parasitic coupling because the width of the path is wide but the distance between two adjacent lines in the zigzagging path is narrow.

FIG. 6 shows the internal antenna of FIGS. 5A and FIG. 5B mounted on a printed circuit board of a portable terminal. Similarly to the embodiment shown in FIG. 2, the antenna is installed such that upper edge of the antenna is displaced upwards from the upper edge of the PCB by a certain offset D2. Also, the antenna may be installed inside the PCB or to be aligned to the edge of the PCB after the ground plane of the PCB is removed as much as the offset, as well.

FIG. 7 shows a standing-wave ratio pattern of the internal antenna of FIGS. 5A and 5B. In the drawing, the horizontal axis indicates a frequency range [MHZ] and the vertical axis indicates a reflection loss[dB]. The internal antenna according to the present embodiment shows a wide bandwidth characteristics of having an operation bandwidth of about 460 MHZ (1.74 - 2.2 GHz) for a reference standing-wave ratio of 2:1. Here, it can be seen in the drawing that another operation bandwidth is formed around 813MHz due to the zigzag signal path in the second conducting plate 220.

FIG. 8A and FIG. 8B show yet another embodiment the internal antenna according to the present invention. FIG. 8A is a perspective view of the internal antenna seen from the upper side and FIG. 8B is a perspective view of the antenna seen from the lower side. Compared with the embodiment of FIGS. 5A and FIG. 5B, the internal antenna according to the present embodiment includes a ground connection conducting plate 350 for connecting a second conducting plate 320 to a ground conductor 300. Also, the antenna includes a feeding conductor plate 370 for feeding power in the lower position of the antenna. A number of slits 327, 328, 302, and 304 are formed in the left side of a second conducting plate 320 and a ground conductor 300. Also, slits 342 and 344 are formed

periodically in a first vertical conducting plate 340 to provide another transmission path. form another transmission line. One slit 312 is formed in a first conducting plate 310. The zigzag path formed in the right side of the second conducting plate is connected to the first vertical conducting plate 340.

The feeding conductor plate 370 is directly coupled to the internal circuit of the terminal by soldering, for example, for feeding signal to the first and the second conducting plates 310 and 320 and the ground conductor 300 through the first vertical conducting plate 340. Two types of transmission paths are formed on the second conducting plate 320 owing to the various slits 322, 324, 325, 326, 327 and 328 of a various shape. The signal feeding through the first vertical conducting plate 340 connected to such transmission paths result in two resonant frequency bands as shown in FIG. 10.

The zigzag path in the left side of the second conducting plate 320 and the zigzag path in the ground conductor 300 connected to the second conducting plate 320 through the ground connection conducting plate 350 increase a total length of the signal path and enhances the resonance characteristics in a low frequency band as shown in FIG. 10. The zigzag path in the left side of the second conducting plate 320 having a narrow width compared with the wide slits increases the inductive reactance component. The tuning of operation frequencies and the adjustment of bandwidth may be carried out by changing the widths and the lengths of the slits.

FIG. 9 shows the internal antenna of FIGS. 8A and FIG. 8B mounted on a printed circuit board of a portable terminal. Similarly to the embodiment shown in FIGS. 2 and

6, the antenna is installed such that upper edge of the antenna is displaced upwards from the upper edge of the PCB by a certain offset.

FIG. 10 shows a standing-wave ratio pattern of the internal antenna of FIGS. 8A and 8B. In the drawing, the horizontal axis indicates a frequency range [MHZ] and the vertical axis indicates a standing-wave ratio. It can be seen in the drawing that the bandwidth of the lower frequency band is increased, compared with the embodiment of FIGS. 5A and 5B, because of the transmission path formed in the left side of the second conducting plate 210 and the ground conductor 300.

Although the present invention has been described in detail above, it should be understood that the foregoing description is illustrative and not restrictive. Those of ordinary skill in the art will appreciate that many obvious modifications can be made to the invention without departing from its spirit or essential characteristics. Thus, it should be apparent that the invention can be modified in arrangement and detail without departing from such principles. We claim all modifications and variation coming within the spirit and scope of the following claims.

Industrial Applicability

As described above, the internal antenna according to the present invention is comprised of radiators made of metallic conducting plates only and does not employ any dielectric material other than air. In case that the antenna is implemented using metallic thin films so that any radiator supporting member is not required, the antenna may show a radiation efficiency of nearly 100% and can be further miniaturized. Also, mass

production is facilitated through an automated process because the antenna can be mounted directly on the PCB of the terminal.

The antenna shows a wide bandwidth due to the introduction of the adjacent dual patches and the vertical patch. An antenna according to an embodiment of the present invention, which has a size of 30 x 12 x 4 [mm], has shown an operation band width over 420 MHZ, about four times that of a conventional antenna. An adjustment of central frequency can be adjusted easily by changing the slits.

The internal antennas may be used for cellular phones or the other kinds of portable terminals.

What is claimed is:

1. An internal antenna mounted on a printed circuit board of a portable terminal having a ground plane and a feeding point, comprising:

a ground conductor electrically connected to the ground plane of the printed circuit board;

a first conducting plate disposed parallel with said ground conductor displaced by a predetermined distance;

means, connected to said first conducting plate, for feeding signal from the feeding point to said first conducting plate and feeding signal from said first conducting plate to the feeding point;

a second conducting plate disposed parallel with said first conducting plate; and

a connection conducting plate for connecting said first conducting plate to said second conducting plate.

2. The internal antenna as claimed in claim 1, further comprising:

a vertical conducting plate extending vertically from an edge of said second conducting plate to be electrically connected to said ground conductor.

3. The internal antenna as claimed in claim 1, wherein at least one slit is formed penetrating said first conducting plate to provide a signal path.

4. The internal antenna as claimed in claim 2, wherein at least one slit is formed penetrating said second conducting plate to provide a signal path.

5. The internal antenna as claimed in claim 4, wherein a penetrating hole for dividing signal and a first slit extending from an edge of the penetrating hole are provided in said second conducting plate.

6. The internal antenna as claimed in claim 5, wherein a "L"-shaped second slit spaced apart from the first slit by a predetermined distance and a third slit for inducing a current perturbation between an edge of said second slit and the penetrating hole is further provided in said second conducting plate.

7. The internal antenna as claimed in claim 1, further comprising:

a vertical radiating plate extending vertically from an edge of said first conducting plate toward said second conducting plate.

8. A method of mounting an internal antenna of claim 1 on a printed circuit board of a portable terminal, comprising the steps of:

disposing the internal antenna so that a upper edge of the internal antenna is displaced outwards from an edge of the printed circuit board by a predetermined distance; and

connecting the ground conductor to a ground of the printed circuit board, and connecting the feeding means to a feeding point of the printed circuit board.

9. A method of mounting an internal antenna of claim 1 on a printed circuit board of a portable terminal, comprising the steps of:

removing a predetermined portion of a ground plane of the printed circuit board close to an edge;

disposing the internal antenna on the printed circuit board on which the ground plane is removed; and

connecting the ground conductor to a ground of the printed circuit board, and connecting the feeding means to a feeding point of the printed circuit board.

FIG. 1A

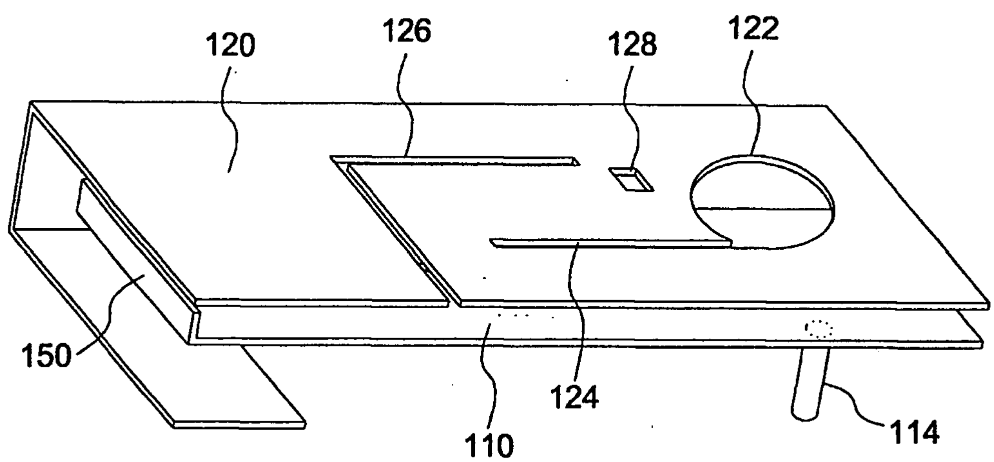


FIG. 1B

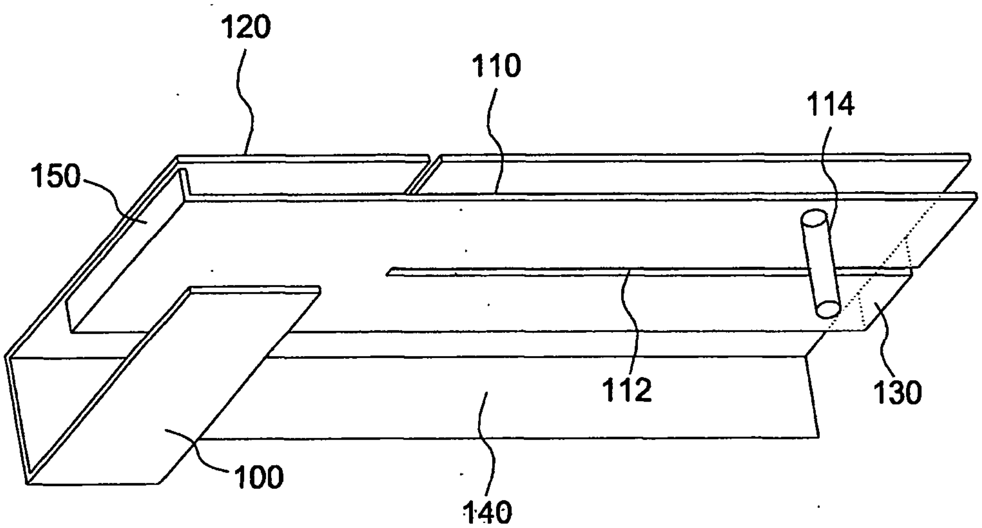


FIG. 2

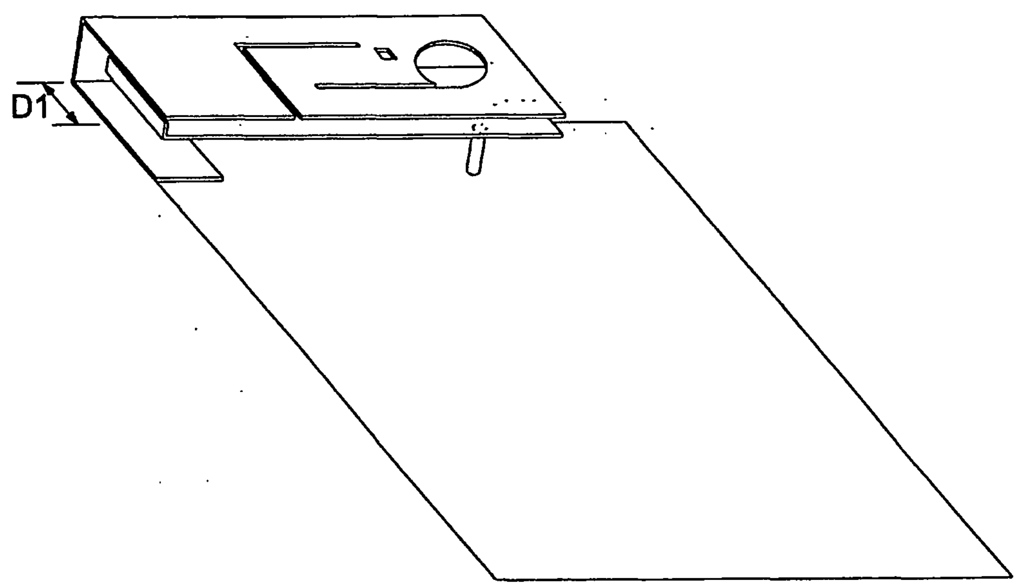
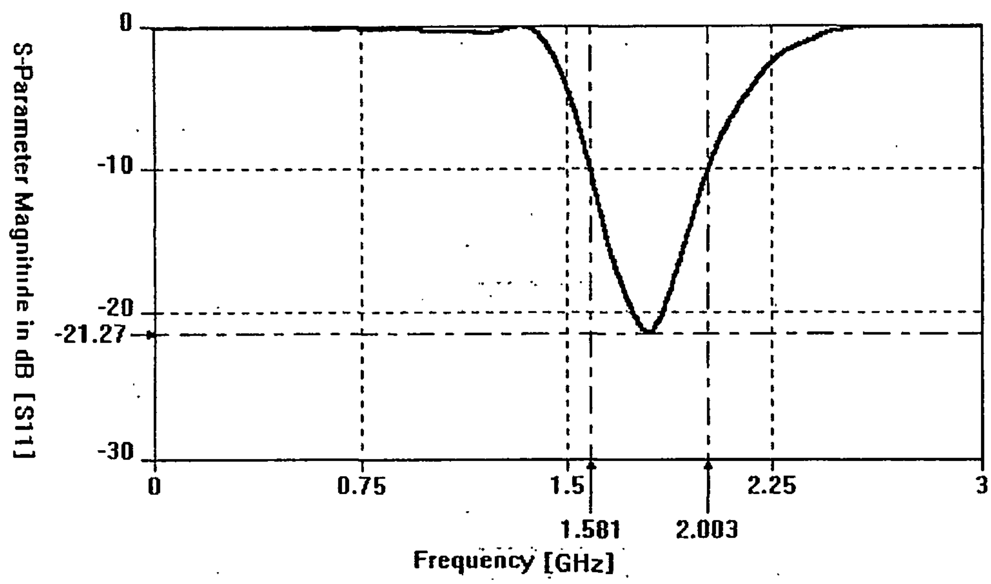


FIG. 3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-30
0
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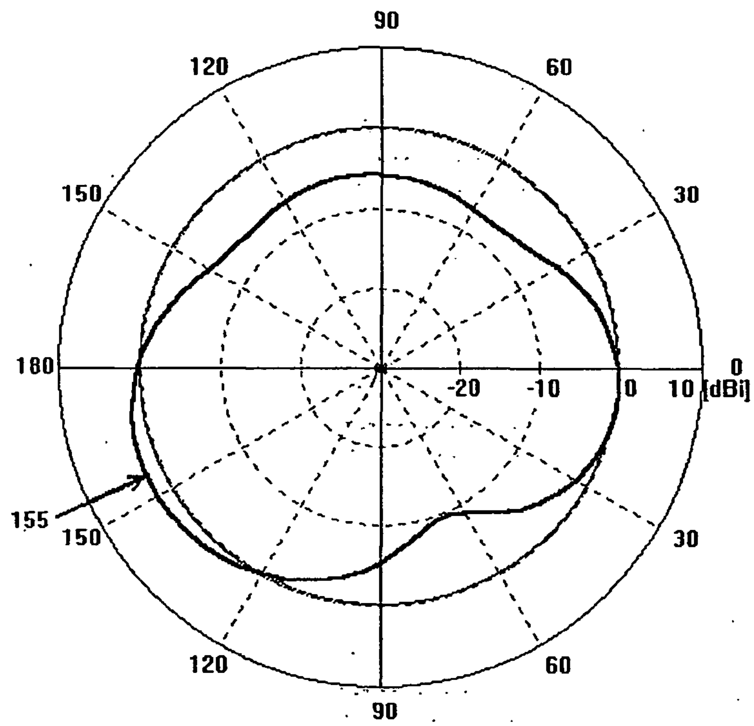
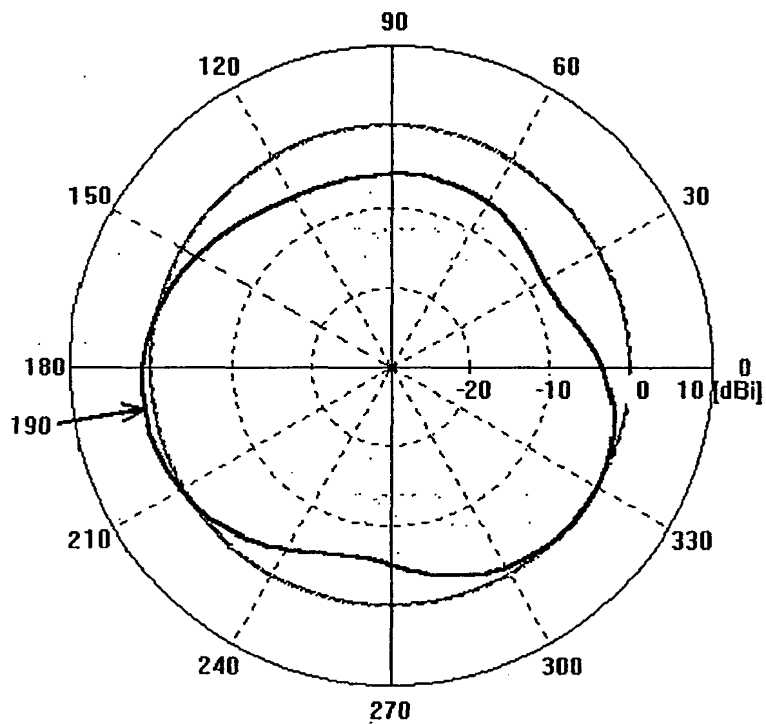
1.5
2.25
3
1.581
2.003
Frequency [GHz]

FIG. 4A



Frequency = 1.8 GHz
main lobe magnitude = 2.1 dBi
main lobe direction = 155.0 deg.

FIG. 4B



Frequency = 1.8 GHz
main lobe magnitude = 1.3 dBi
main lobe direction = 190.0 deg.

FIG. 5A

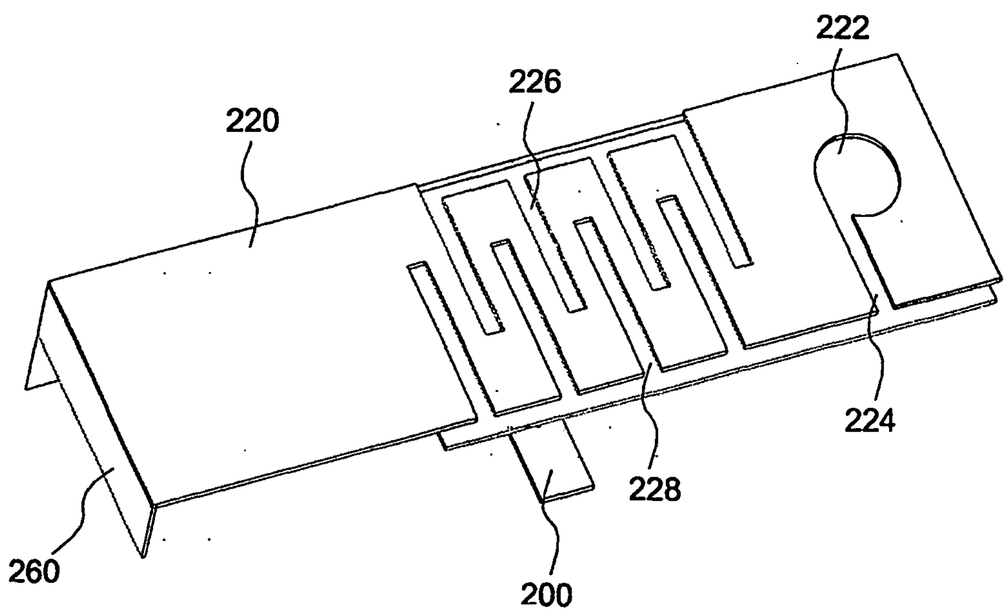


FIG. 5B

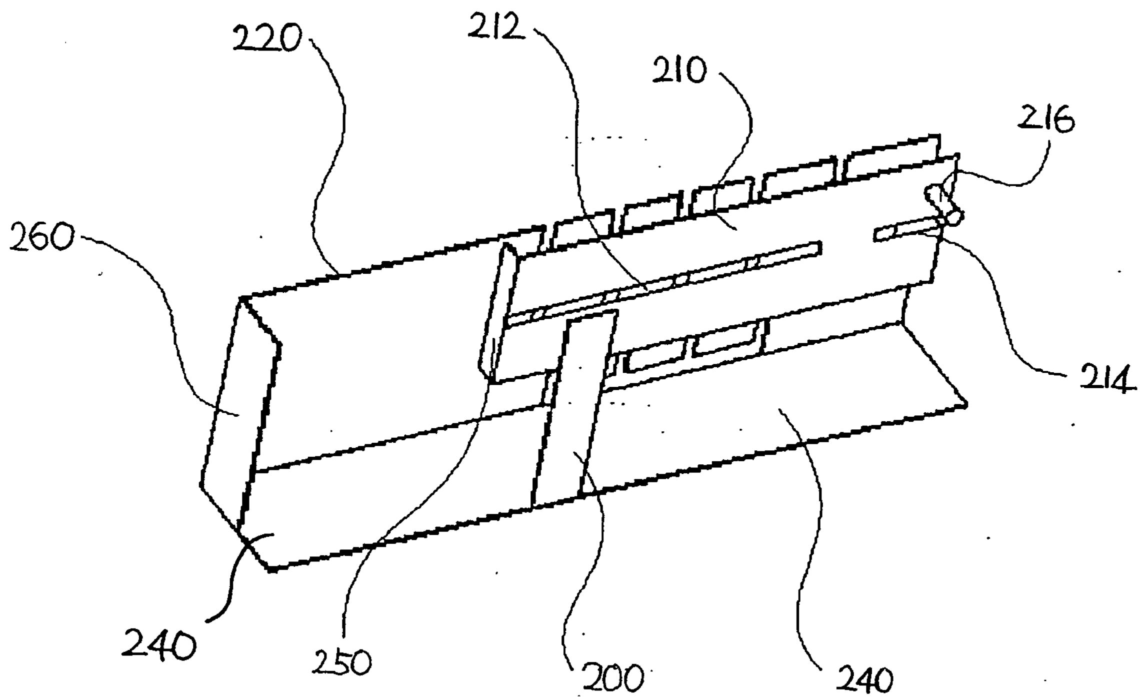


FIG. 6

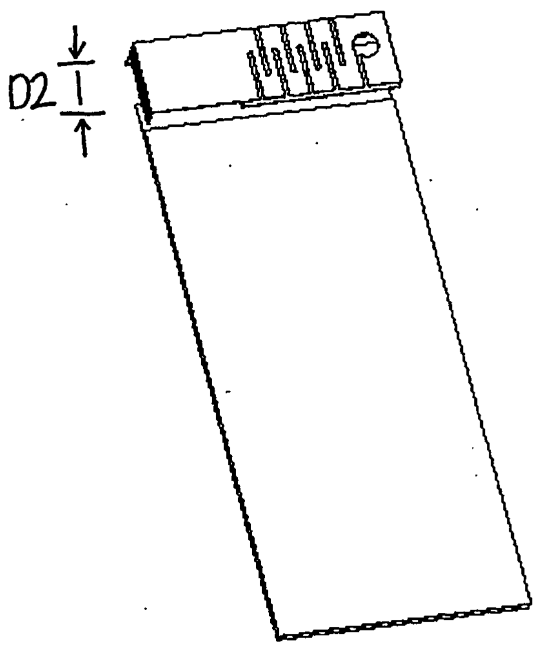
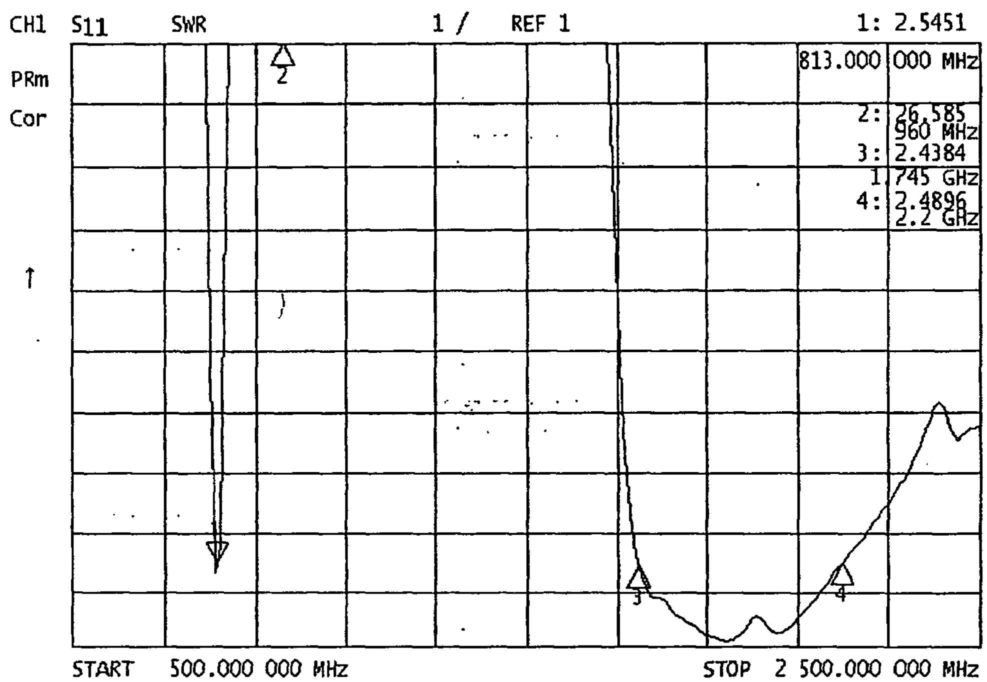


FIG. 7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START 500.000 000 MHz
STOP 2 500.000 000 MHz

FIG. 8A

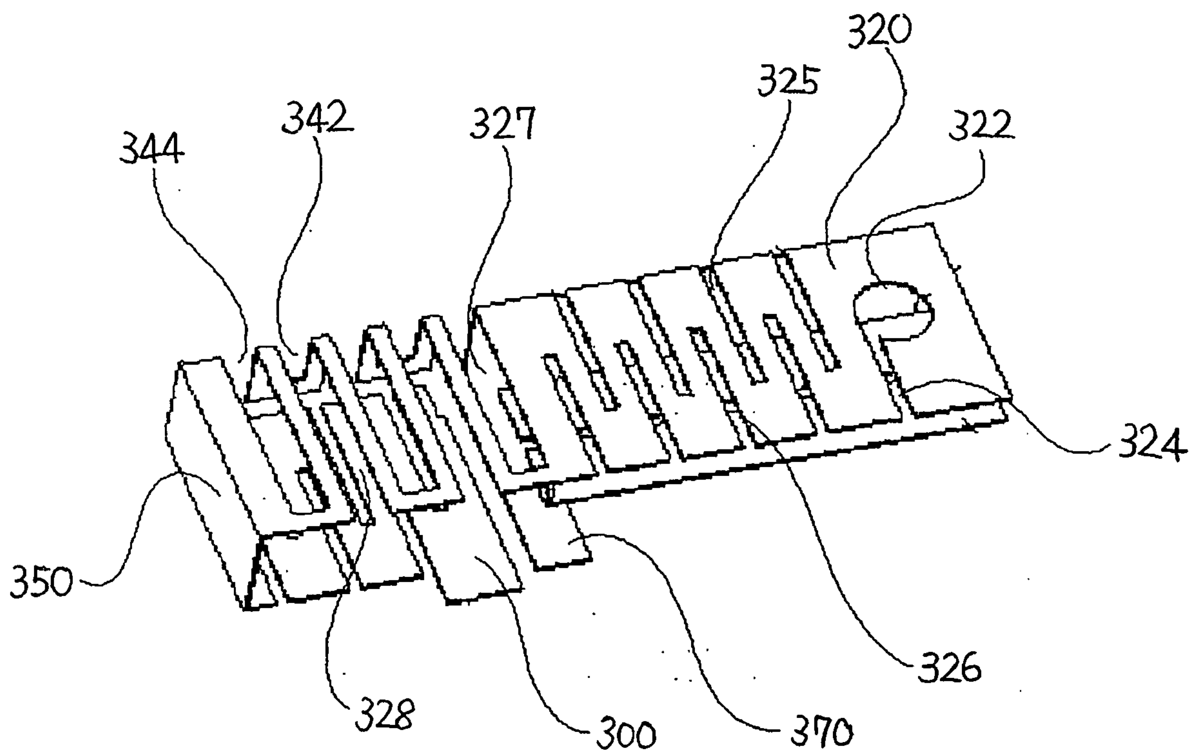


FIG. 8B

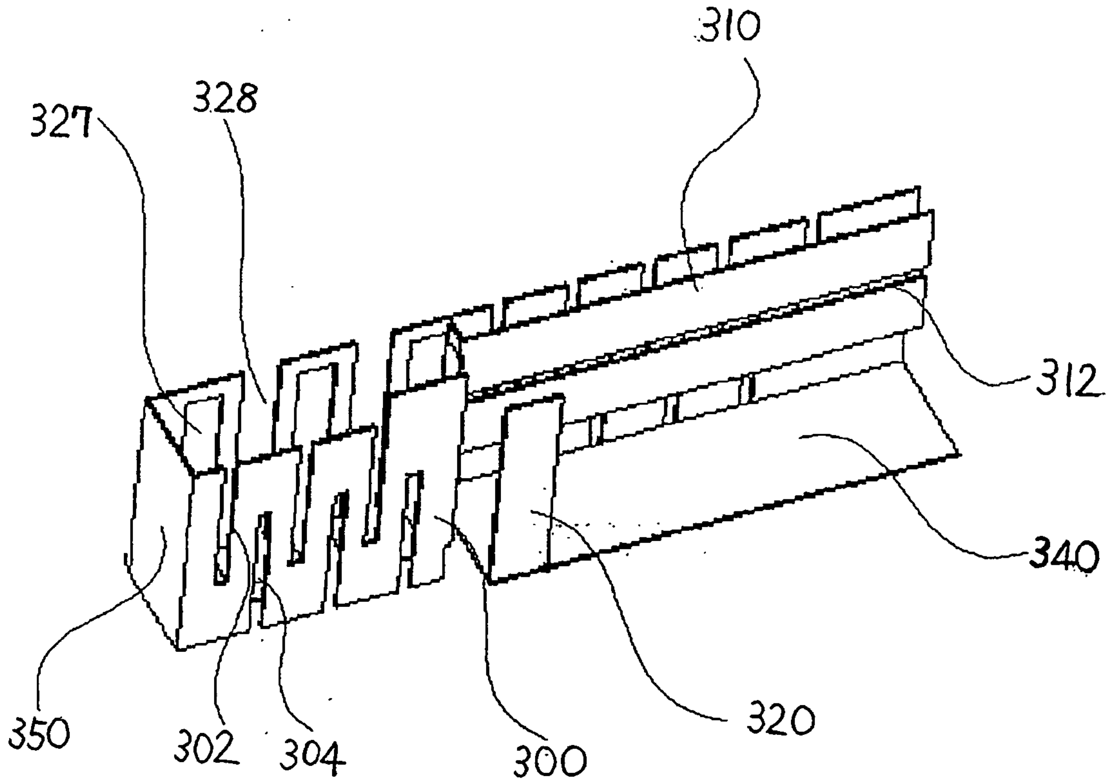


FIG. 9

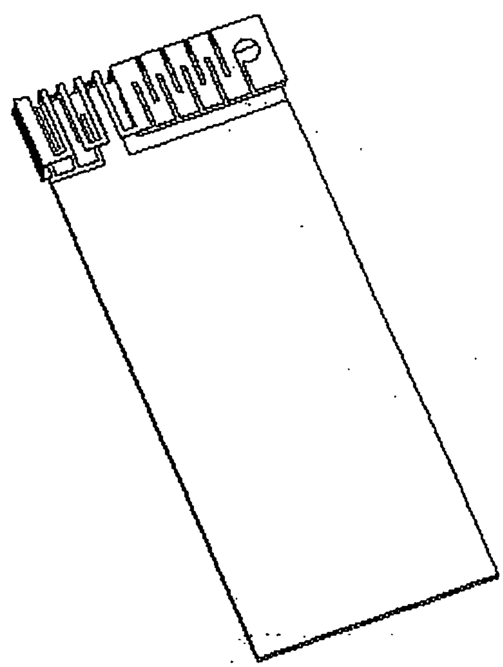
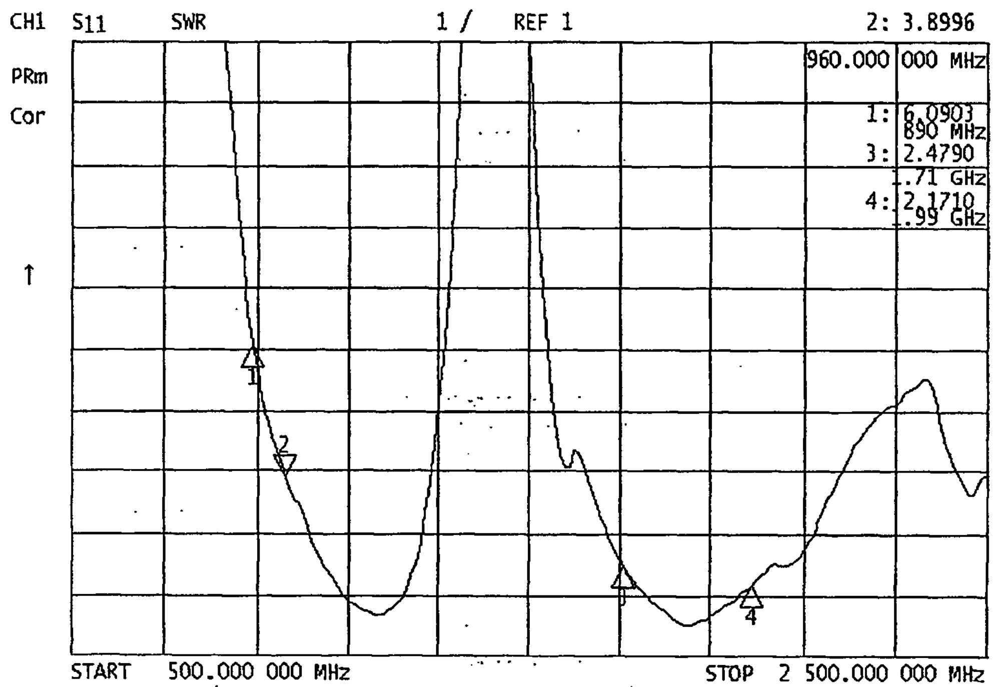


FIG. 10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2
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4
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/01673

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H01Q 23/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

H01Q 1/38, H01Q 13/08

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and Applications for Inventions since 1975
Korean Utility Models and Applications for Utility Models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trems used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 60058704 A (NTT) 04 April 1985 See Figs. 7, 8	1 - 9
A	WO 96/27219 A1 (Chinese Univ. of H.K.) 06 Sep. 1996 See Abstract and Figs. 1-3	1 - 9
A	WO 99/28990 A1 (Toshiba) 10 Jun. 1999 See Abstract and Fig. 1	1 - 9

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

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